#5
9-15-99

State of New York)
: SS:
County of New York)

AFFIDAVIT

On this day, Richard B. Grose personally appeared before me and after being duly sworn, deposes and states:

That he is qualified as a translator of German into English and is employed as such by Kenyon & Kenyon (One Broadway, New York, New York 10004:

That he has carefully reviewed the attached English translation from the original document,

"Verfahren zum Erzeugen von Crashsignalen [Process for Generating Collision Signals]"

written in German; and

That the attached translation is a true and correct English version of such original to the best of his knowledge and belief.

Richard B. Grose
RICHARD B. GROSE

Subscribed and Sworn to before me

this 18 day of August, 1999.

Barbara Inserra
Notary Public

BARBARA A. INSERRA
Notary Public, State of New York
No. 01IN4882052
Qualified in New York County
Commission Expires December 29, 2002

R. 31136
November 18, 1996 Ti/Gy

ROBERT BOSCH GMBH, 70442 Stuttgart

Process for Generating Collision Signals

Background of the invention

The present invention concerns a process for generating signals which describe various collision events in motor vehicles, where these collision signals are derived from one collision signal actually measured.

It would be desirable to achieve an optimum, stable triggering response of the installed restraint systems (air bags, seat belts, etc.) for each type of motor vehicle. In other words, the restraint systems should be triggered only when the occupants of the vehicle are actually endangered in a collision, and then the restraints should also be triggered with a very high degree of reliability. Faulty triggering of restraint systems is undesirable because it is very expensive to service the restraint systems; insurance companies in particular have a great interest in preventing faulty triggering of restraint systems as much as possible. Therefore, the algorithm controlling the triggering of restraint systems must be adapted individually to each type of vehicle. Calibration of the triggering algorithm is performed using collision data that reflect the behavior of the vehicle body in a wide variety of collision situations. There are essentially three categories of collisions - front and side collisions and repair collisions. Repair collisions should not trigger a restraint system, e.g., bumping of vehicles in parking. Repair collisions occur at low vehicle speeds (≤ 15 km/h). The number of actual collisions of a vehicle should of course be greatly limited for cost reasons. However, to make the triggering algorithm as reliable and stable as possible, it would be

desirable to have access to a large number of collision signals that describe a wide variety of different collision situations.

It is known from the conference paper of ASL at SAE, no. 920480 that measured collision data can be used to generate new synthetic collision data by mathematical methods to describe other collision situations. However, the mathematical method used there to derive new collision signals is very complicated and requires a long computation time. Furthermore, the collisions synthesized by the known method have a poor correlation with collisions that actually occur.

Therefore, the object of this patent application is to provide a process of the type defined in the preamble that will make it possible to generate a plurality of new collision signals representing a wide variety of collision situations with minimal use of computing capacity.

Advantages of the invention

This object is achieved according to the features of Claim 1 due to the fact that a core signal is derived by low-pass filtering from a collision signal actually measured; the core signal is split into several chronologically sequential signal segments; each signal segment is simulated by a transmission function; all the resulting transmission functions are then combined to a overall transmission function; and finally, one or more collision signals are formed by varying at least one parameter of the overall transmission function. The process according to this invention needs only a single collision signal actually measured to derive a plurality of modified collision signals using a simple mathematical method.

Expedient embodiments of this invention are derived from the

subclaims.

Description of one embodiment

The invention is explained in greater detail below with reference to one embodiment illustrated in the figures, which show the following:

Figure 1: a flow chart for the process for deriving new collision signals, and

Figure 2: a collision signal curve.

To generate new synthetic collision signals, a collision signal is measured in an actual vehicle collision in a first process step 1 according to Figure 1 and stored in the form of ASCII data, for example. Figure 2 shows a collision signal curve measured at a certain location in the vehicle as an example. The collision signal represents the change in acceleration or deceleration *a* measured at one location in the vehicle as a function of time during a collision. It can be seen that at the beginning of a collision, the measured acceleration *a* undergoes very great changes that subside over time. The negative values shown on the ordinate axis of the curve indicate that acceleration *a* is negative here, i.e., the motor vehicle experiences deceleration on impact with another object. Time *t* is shown in sampling increments on the abscissa of the curve.

In a second process step 2, a core signal is selected from the measured collision signal. To do so, the measured collision signal is sent through a linear FIR filter (filter with a limited pulse response) that has a low-pass characteristic and a cut-off frequency between 80 and 200 Hz. Due to this filtering, short-period signal peaks are filtered out, leaving a smoothed core

signal at the filter output. The signal curve illustrated in Figure 2 is one such core signal filtered out of the measured collision signal. Upstream from the linear FIR filter there may be a non-linear filter (median filter) with which all signal peaks lasting 1 ms or less are eliminated. The median filter thus performs presmoothing before the linear FIR filter.

The core signal is then split into a plurality of signal segments in process step 3. The boundaries of the individual signal segments, indicated by points in Figure 2, are preferably set so that each signal segment is a pulse from the overall signal curve. To separate the individual pulses, minimums and points of inflection of the signal curve are first determined with the help of known signal sampling methods. A pulse is either between two minimums or between one minimum and one point of inflection. Whether such a pulse represents a suitable signal segment is determined by comparison of the respective pulse with a model pulse. It is advantageous for the model pulse to be a gaussian pulse that can be varied through two parameters. The first parameter is the pulse width ratio on the right and left of the vertical line of symmetry of the pulse at a certain fraction of the overall pulse amplitude. For example, a ratio of 1:5 between the pulse widths on the right and left of the line of symmetry is defined at 75% of the overall pulse amplitude. The second parameter for the model pulse is the ratio between the pulse amplitudes at the edges on both sides of the line of symmetry. This amplitude ratio may be set at 25%, for example. Only when a pulse selected from the signal curve is inside the limits defined by the model pulse with regard to the pulse width ratio and the pulse amplitude ratio is it treated as a suitable signal segment. A pulse that does not meet these prerequisites is added to the next pulse, and together with it, forms a signal segment.

In the next process step 4, each signal segment is simulated by a

transmission function in the *z* plane. This transmission function has the following form, for example:

$$He(z) = \frac{b0+b1z^{-1}+b2z^{-2}}{1+a1z^{-1}+a2z^{-2}+a3z^{-3}} \tag{1}$$

In this transmission function He(z) according to equation (1), six coefficients *b0, b1, b2, a1, a2, a3* are identified for each signal segment.

Then in process step 5, a overall transmission function Hs(z) is formed from all the individual transmission functions He(z) of the signal segments.

This overall transmission function has the following form:

$$Hs(z) = \sum_{i=1}^{s}\sum_{j=0}^{m}\sum_{k=0}^{n} \frac{bjiz^{-1}}{akiz^{-k}} z^{-li} \tag{2}$$

where *i* is the running index for the signal segments, where *s* is the number of segments,
j is the running index for the numerator coefficient *b*, where *m* is the order of the numerator coefficients, and
k is the running index for the denominator coefficient *a*, where *n* is the order of the denominator coefficient,
l is a segment vector that runs from one segment to the next and indicates the sampling step at which the respective segment whose transmission function is to be added to the overall transmission function begins.

In process step 6, new collision signals are generated by parameter variations of the overall transmission function Hs(z). Parameter variation means that coefficients *a* in the overall transmission function are varied. In the transmission function

He(z) selected here, coefficients *a* of the denominator of the overall transmission function Hs(z) form a third-order polynomial in the complex z plane. The roots of this polynomial are the poles of the overall transmission function. Since this is a third-order polynomial, there is a real pole and a conjugated complex pole pair. New collision signal curves are obtained by varying the locus of at least one complex pole within a circle with radius 1 in the complex z plane (a circle with radius 1 describes the stability limit).

Variation of the zero positions, i.e., coefficients *b* in the numerator, is of no use because it has no effect on the frequency spectrum of the overall transmission function Hs(z) but instead it affects only its amplitude. This variation would create only new collision signals with a varied amplitude but would not alter the shape of the collision signals.

The measure of the variation of the denominator coefficients *a* of the overall transmission function Hs(z) to generate new collision signals that are as realistic as possible is based on calculations of the correlation and the energy deviation (deviation in effective values) between synthetic collision signals and real collision signals. Experience indicates that variations of 0.1% to 1.0% lead to synthetic collision signals having a close correlation with real collisions.

In deviation from the embodiment described above, an even higher-order transmission function can be used instead of a third-order transmission function. Likewise, even a second-order transmission function can be used.

The process on which this invention is based makes it possible to derive new collision signals from core signals with a rather high filter cut-off frequency of up to 200 Hz. This guarantees that

important information on the collision signal actually measured is preserved in generating synthetic collision signals.

The collision signal actually measured is composed of the core signal selected by filtering and a residual signal. The residual signal can also be varied and superimposed on the varied core signal to synthesize new collision signals.

November 18, 1996 Ti/Gy
ROBERT BOSCH GMBH, 70442 Stuttgart

Claims

1. Process for generating signals that describe various motor vehicle collision processes, where these collision signals are derived from a collision signal actually measured, characterized in that

- a core signal is derived by low-pass filtering from the collision signal actually measured,
- the core signal is split into several chronologically sequential signal segments,
- each signal segment is simulated by a transmission function,
- all the resulting transmission functions are combined to form a overall transmission function,
- and one or more new collision signals are formed by varying at least one parameter of the overall transmission function.

2. Process according to Claim 1, characterized in that the core signal is split into individual pulses representing the individual signal segments.

3. [Process] according to Claim 1 or 2, characterized in that the signal segments are determined by comparison of the single pulses with a model pulse, the model pulse is a gaussian pulse that can be varied through a plurality of parameters, and a single pulse is accepted as a separate signal segment when the single pulse is within limits that can be preset relative to the model pulse.

4. Process according to Claim 1, 2 or 3, characterized in that the individual signal segments are simulated by a transmission

function in the complex z plane of the form:

$$He(z) = \frac{b0+b1z^{-1}+b2z^{-2}}{1+a1z^{-1}+a2z^{-2}+a3z^{-3}}$$

5. Process according to Claim 1 or 4, characterized in that the overall transmission function has the form:

$$Hs(z) = \sum_{i=1}^{s} \sum_{j=0}^{m} \sum_{k=0}^{n} \frac{bjiz^{-1}}{akiz^{-k}} z^{-li}$$

where *i* is the running index for the signal segments, with *s* being the number of segments,
j is the running index for numerator coefficient *b*, with *m* being the order of the numerator coefficient,
k is the running index for denominator coefficient *a*, with *n* as the order of the denominator coefficient,
l is a vector that denotes the boundaries of the signal segments.

6. Process according to Claim 5, characterized in that at least one complex pole in the overall transmission function is varied to form new collision signals.

R. 31136

November 18, 1996 Ti/Gy

ROBERT BOSCH GMBH, 70442 Stuttgart

Process for generating collision signals

Abstract

A relatively uncomplicated method for generating collision signals that describe various collision processes involving motor vehicles consists of deriving a core signal by low-pass filtering from a collision signal actually measured, splitting this core signal into several signal segments, simulating each signal segment by a transmission function, then combining all the transmission functions into one overall transmission function, and forming one or more new collision signals by varying at least one parameter of the overall transmission function.

(Figure 1)

Figure 1

1 - Measured collision signal;

2 - Select core signal;

3 - Split into signal segments;

4 - Signal segment transmission functions;

5 - Overall transmission function;

6 - Parameter variations

T:\NY2DOCS\TRL\PF01\136725-1-10191-538